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IJSRNSC

Volume-5, Issue-1, April 2017
Research Paper

Int. J. Sc. Res. in
Network Security
and Communication

ISSN: 2321-3256

Improvement in Gain and Bandwidth using Current Mode Technique

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Received 18th Feb 2017, Revised 04th Mar 2017, Accepted 24th Mar 2017, Online 30th Apr 2017

Abstract — Nowadays in Modern wireless Receiver, high speed data availability and increased usage of wireless devices has increased challenges in improving battery life. In voltage mode circuits shows poor performance in various parameter like gain, bandwidth, power consumption. To overcome of this disadvantage current mode are much more beneficial. Due to exponential increase in users, bandwidth requirement also increased. In any communication system, current mode receiver will be beneficial from high data rate receiving point of view. In this paper, a current mode receiver which can operate at very low voltage and provide high frequency at the output. For this, a current-mode device is modeled and using this modeled device, the various circuit blocks are simulated using H-SPICE software. The proposed current mode receiver can work at very low voltages and consume less power, compare to voltage mode receiver.

Index Terms**—**CM (current-mode), VM (voltage-mode), power consumption, CC (current conveyor), CFA (current feedback amplifier)

I. INTRODUCTION

Many communication systems are based on voltage mode. Especially take part of the receiver is available in voltage mode. Using this voltage mode circuit its shows low performance of bandwidth. Also gain bandwidth dependency major problem obtain. Due to this dependency it is difficult to handle it separately. To overcome of this disadvantage Current mode used. In current mode circuits shows gain bandwidth in-dependency so it is possible to handle both parameters separately. Also cm circuits operate at low voltage. This is big advantage of current mode. There are AM and FM available but in digital system FM parameter over AM gives better performance. Therefore we are designing FSK receiver in cm. A receiver in pulsed radar system consists of a trigger source that generates pulses of appropriate time and frequency which are fed to modulator. The demodulator provides rectangular voltage pulses which are used as supply voltage for the output tube. These rectangular pulses switch on and off the output tube. This output tube may be a magnetron oscillator, traveling wave tube or klystron amplifier. The high powered output of tube is coupled to antenna by a duplexer. The FM microwave receiver consists of a pre emphasis network precedes the FM deviator. The pre-emphasis network provides an artificial boost in amplitude to the higher baseband frequencies. This allows the lower baseband frequencies to frequency modulate the IF carrier and the higher base-band frequencies to phase modulate it. This scheme ensures a more uniform signal- to-noise ratio throughout the entire baseband spectrum. An FM deviator provides the modulation of the IF carrier that eventually becomes the main microwave carrier. Typically IF carrier frequencies are between 60 MHz and 80 MHz Low- index frequency modulation is used in the FM deviator. All the above communication systems are available in VM which operates at high voltages. For efficient bandwidth and for low power dissipation, the CM communication system is a good option. Due to the advantages of current mode building blocks, CM communication system is developed in this paper. The 2nd section that give the information about cm building blocks. Why we used BJT based CFA over all over all cm circuits that are explained. 3rd section about MOSFET based CFOA and the 4th section shows cm FSK receiver [1-12].

II. CURRENT MODE BUILDING BLOCKS

The current signals can be easily replicated and scaled using current mirrors. This reduces the complexity of the circuit operating in current mode (CM) compared to that operating in voltage mode (VM). The CM building blocks can operate with low voltages. They have higher bandwidth and slew rate as compared to voltage-mode (VM) building blocks. Further, the CM building blocks can offer gain-bandwidth in-dependency compared to VM building blocks as can be seen from the frequency response of a simple amplifier as shown in figure 1. Because of this property of gain-bandwidth in-dependency in figure 2 in CM building blocks, the CM building blocks can be used for various applications at very high frequency.

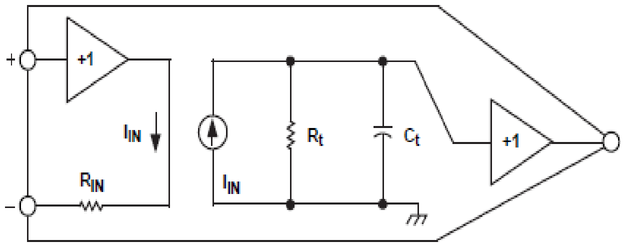

Fig.1.Internal Structure of CFA

Current-mode (CM) filters are attractive because of their wider bandwidth, higher slew rate, wider dynamic range and lower power consumption compared to voltage-mode (VM) component. However, a large number of op-amp (OA)-based VM circuits with excellent performance and their elegant realization procedures were put forward in the past. It is, therefore, worthwhile to convert them into CM circuits. FTFN (Four terminal floating nullor)[8], CC (current conveyor) and CFA (Current Feedback Amplifier), current differencing buffered amplifier (CDBA), and operational trans-resistance amplifier (OTRA) based CM circuits have received considerable attention in many signal processing applications, particularly, the CFA-based circuits are attractive due to the high slew rate and bandwidth independent of closed loop gain.[5]

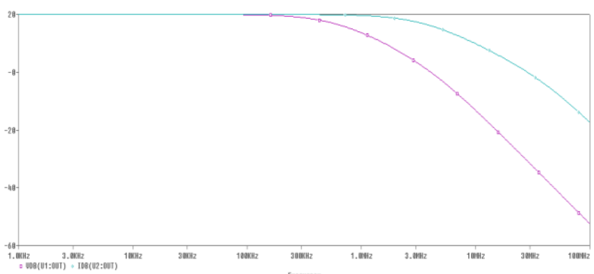

Fig.2.Gain-Bandwidth in-dependency

The BJT based CFA is shown in figure 3. There is buffer between the non inverting input terminal 2 and the inverting input terminal 3.

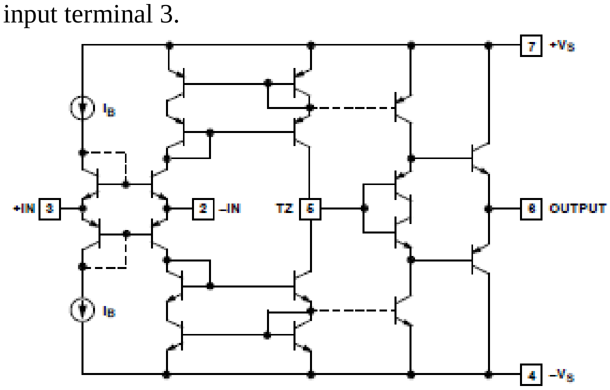

Fig.3.BJT Based CFA

Also, CFA has both the output i.e. in voltage as well as in current form. In this paper, CFA based CM receiver is derived.

A. Current Feedback Amplifier

The terminal characteristics of the current feedback amplifier (CFA) also known as current feedback operational amplifier (CFOA) are:

$$\begin{bmatrix} V_x \\ I_y \\ I_z \\ V_w \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} I_x \\ V_y \\ V_z \\ I_w \end{bmatrix}$$

On the output side, there is a current-controlled voltage source of the strength Z where Z is the forward dynamic transfer impedance of the device (modeled as the parallel combination of R_T and C_T) and I is the current following out of the inverting input terminal. For an ideal CFA shown in Fig. 4, R = 0 and Z = ∞. The CFA was released by Analog Devices as early as in 1984[3-4]. IC LM 675 is used for this purpose as it has wider bandwidth of 65 MHz which is comparable to CFA AD 844. The simulation result is shown in figure 8.The total power consumed by VM receiver circuit is 291 mW. Using VM to CM transformation technique [2] here, the input to the modulator is taken from the voltage output terminal (w terminal). The total power consumed by CM transmitter circuit is 123 mW. If the currents are taken as input to the modulator from the z terminal of CFA. The Sallen key Band pass filter is used with two different frequencies which receive frequency from transmitter. Then rectified output of the signal which compare through comparator. Design value is 1MHz.

III. MOSFET BASED CFOA

By using proper Aspect ratio we have converted BJT based CFA into CFOA MOSFET 180 nanometer technology used.

Code for CFOA

```
*CFOA_AD844+
*.............................VSS
*...........................VDD |
*..........................W  ||
*.......................Z  | ||
*.....................X | | ||
*...................Y || | ||
.SUBCKT CFOA_AD844+ 4 8 18 10 1 11

.include p18_cmos_models_tt.inc
*MOSFET CIRCUIT
M1 3 3 4 4 nmos w=60u l=0.18u
```


M2 7 3 8 8 nmos w=60u l=0.18u
M3 5 5 4 4 pmos w=90u l=0.18u
M4 9 5 8 8 pmos w=90u l=0.18u
M5 7 7 1 1 pmos w=28u l=0.18u
M6 10 7 1 1 pmos w=28u l=0.18u
M7 9 9 11 11 nmos w=17u l=0.18u
M8 10 9 11 11 nmos w=17u l=0.18u
*w section*****************
MWP1 16 7 1 1 pmos w=28u l=0.18u
MWP2 11 10 16 16 pmos w=28u l=0.18u
MWN1 1 10 17 17 nmos w=17u l=0.18u
MWN2 17 9 11 11 nmos w=17u l=0.18u
MWN3 1 16 18 18 nmos w=17u l=0.18u
MWP3 11 17 18 18 pmos w=28u l=0.18u
*supplies
Ibias1 1 3 120u
Ibias2 5 11 120u
.ends

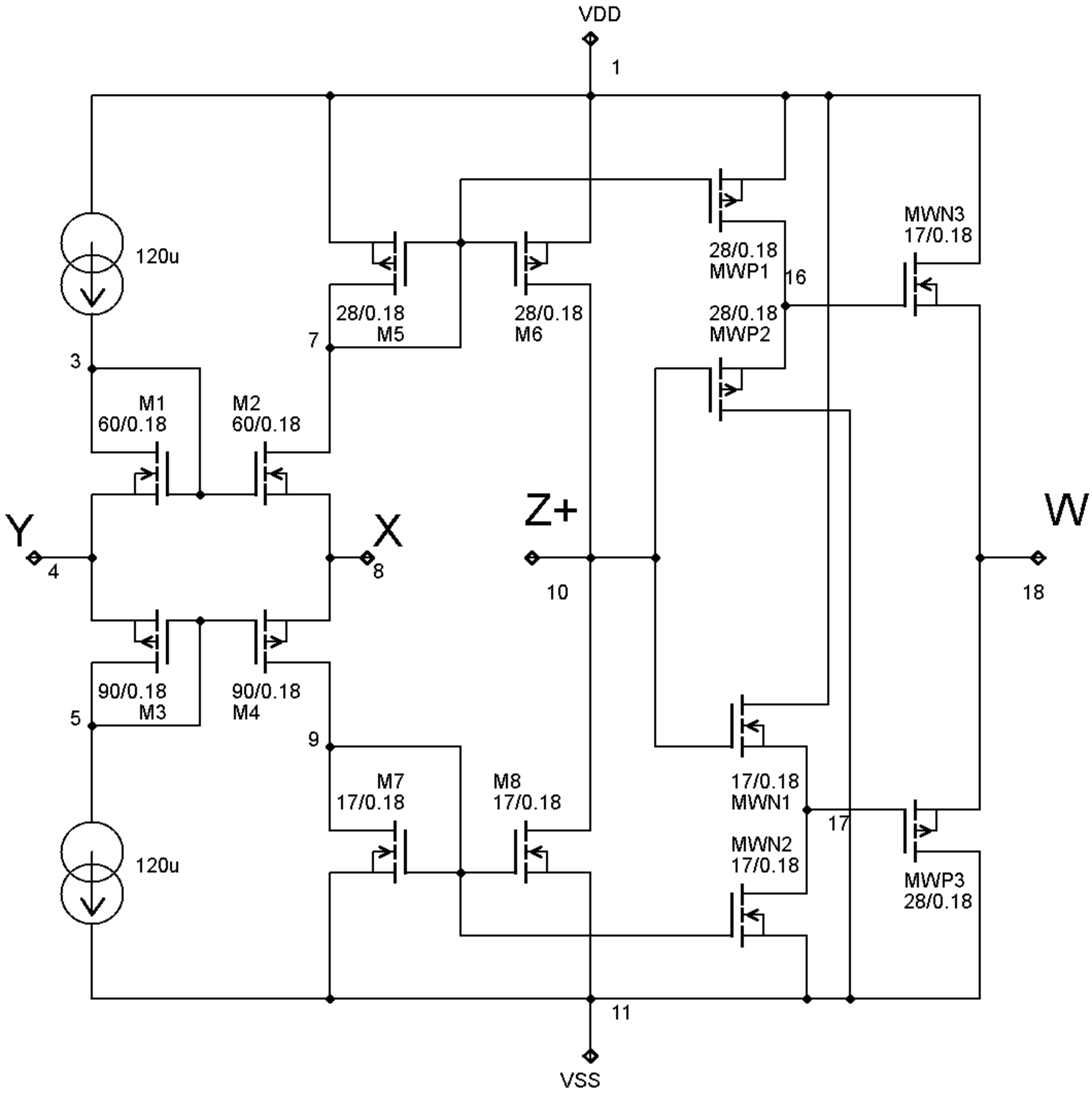

Fig.4.MOSFETbased CFA

IV. PROPOSED CM RECEIVER USING MOSFET BASED CFA

While designing the model for CFA, the proper aspect ratios for CMOS are used so as to follow the characteristic matrix of CFA in matrix equation. Using this modeled CFA, a circuit file is devised for a receiver section of Fig.5. Because of the space constraint, a code for the CFOA is given and is simulated using HSPICE software. The receiver is operated at a very low voltage of 1V. The total power consumed by CM receiver circuit is 2.2357 mW. Because of device level, it has become feasible to achieve low power consumption in CM receiver. The modulated signal from the transmitter is received by sallen key filter, which produce two different frequencies. This frequency envelop are detected by rectifier. Filter converted into dc signal in which comparator produced demodulated signal. Sallen key band pass filter is used in receiver. The amplifier is used as MOSFET based CFOA.

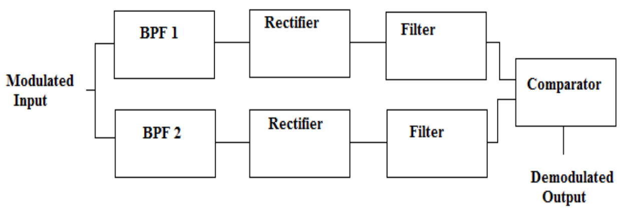

Fig.5.FSK Receiver

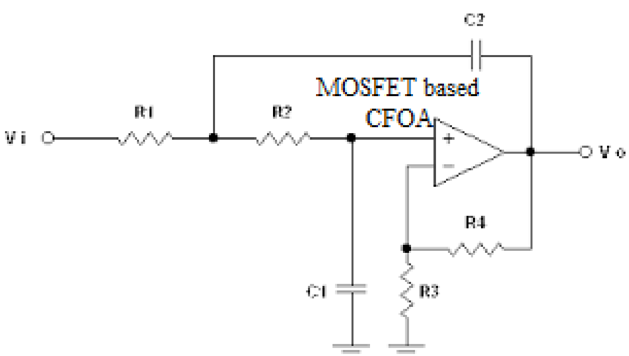

Fig.6.Sallen Key

Sallen key band pass filter is used in receiver. The amplifier is used as MOSFET based CFOA.

Code foe Sallen Key

```
Bpfilter
*.ac dec 10 1 1e6
.tran 10000n 1m 0s
*.print vtggaina = PAR('v(6a)/v(ina)')
*.print vtggainb = PAR('v(6b)/v(inb)')
.include ad844s.cir
**********************************************
*V1 ina 0 ac 1.5
*V1 ina 0 ac sin(0 1 3k 0 0)
V1 ina 0 SIN (0 1V 3kHz 0 0 0)

Vdda 7a 0 dc 10
Vssa 0 4a dc 10

R1a 1a ina 26.5k
R2a 6a 2a 106k
R3a 1a 0 268
R4a 5a 0 100k
C1a 6a 1a .01u
C2a 2a 1a .01u
X1 0 2a 7a 4a 6a 5a AD844S
********************************************
*V2 inb 0 ac 1.5
*V2 inb 0 ac sin(0 1 6k 0 0)
V2 inb 0 SIN (0 0V 6kHz 0 0 0)
R1b 1b inb 31.262k
R2b 6b 2b 53k
R3b 1b 0 133.96
R4b 5b 0 100k
C1b 6b 1b .01u
C2b 2b 1b .01u
X2 0 2b 7a 4a 6b 5b AD844S
***********************************************
*R5c 5c 0 100k
*X3 6a 6b 7a 4a 6c 5c AD844S
.probe V(6c)
********************************************
.end
```

The demodulated output is obtain at the end of the receiver. Figure 7 shows that the desire dc output.

Fig.7.Output Waveform of sallen key

The bandwidth increases and independent upon the gain in the current mode circuits as compare with the circuits in voltage mode as shows in figure 8.The red color shows the gain of voltage mode circuit less than 1MHz and Green color shows current mode output which is more than 1MHz as shown in figure 8.

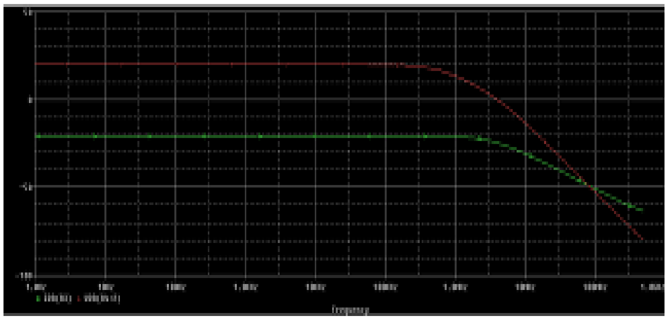

Fig.8.Difference between Cm-Vm

TABLE 1
Comparative study of Power consumption

Circuit	Output Power
Voltage mode receiver at Circuit level	291mW
Current mode receiver at Circuit level	123 mW
Current mode receiver at Device level	2.2357 mW

There is a 98 % reduction in power consumption seen in device based receiver section as compared to circuit based transmitter section. Thus, the overall CM communication system will have 30 to 40% reduction in power consumption as compared to that of VM communication system.

V. CONCLUSION

Current mode receiver is beneficial from high data rate transmission point of view. A current mode receiver which can operate at very high frequency in MHz is presented here. This has become feasible because of gain-bandwidth independency of current mode building blocks such as CFA (AD844). The proposed current mode receiver can work at very low voltages and consume less power, 123 mW compare to voltage mode receiver, 291 mW.

VI. ACKNOWLEDGMENT

The authors would like to thanks Dr. D. J. Pethe for his kind support and guidance in this work

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